CHROMIUM

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In 2002, the U.S. chromium supply (measured in contained chromium) was 139,000 metric tons (t) from recycled stainless steel scrap, 263,000 t from imports, and 705,000 t from Government and industry stocks. Supply distribution was 28,700 t to exports, 604,000 t to Government and industry stocks, and 483,000 t to apparent consumption. Chromium apparent consumption increased by 48.2% compared with that of 2001.

The United States exported about 65,904 t, gross weight, of chromium-containing materials valued at about $67.6 million and imported about 512,512 t, gross weight, valued at about $256 million.

Chromium has a wide range of uses in chemicals, metals, and refractory materials. Its use in iron, nonferrous alloys, and steel is for the purpose of enhancing hardenability or resistance to corrosion and oxidation; production of stainless steel and nonferrous alloys are two of its more important applications. Other applications are in alloy steel, catalysts, leather processing, pigments, plating of metals, refractories, and surface treatments.

Chromium is an essential trace element for human health. Some chromium compounds, however, are acutely toxic, chronically toxic, and/or carcinogenic. The U.S. Environmental Protection Agency (EPA) regulates chromium releases into the environment. The Occupational Safety and Health Administration (OSHA) regulates workplace exposure.

Because the United States has no chromite ore reserves and a small reserve base, domestic supply has been a concern during every national military emergency since World War I. World chromite ore resources, mining capacity, and ferrochromium production capacity are concentrated in the Eastern Hemisphere. World chromite ore reserves are more than adequate to meet anticipated world demand. In recognition of the vulnerability of long supply routes during a military emergency, chromium was held in the National Defense Stockpile (NDS) in various forms, including chromite ore, chromium ferroalloys, and chromium metal. As a result of improved national security, stockpile goals have been reduced, and inventory is being sold. Material for recycling is the only domestic supply source of chromium.

The U.S. Geological Survey (USGS) has conducted mineral-resource surveys of the United States to assess the potential for occurrences of chromium and other mineral resources. The National Aeronautics and Space Administration, the National Institute of Standards and Technology, the U.S. Department of Defense (DOD), and the U.S. Department of Energy conduct alternative materials research.

Legislation and Government Programs

The Defense National Stockpile Center (DNSC) disposed of chromium materials under its fiscal year (FY) 2002 (October 1, 2001, through September 30, 2002) Annual Materials Plan (AMP). The DNSC's FY 2002 AMP (as revised in April) set maximum disposal goals for chromium materials at 136,000 t of chromium ferroalloys, 90,700 t of chemical-grade chromite ore (or remaining inventory), 90,700 t of metallurgical-grade chromite ore (or remaining inventory), 90,700 t of refractory-grade chromite ore, and 454 t of chromium metal. The Defense Logistics Agency also developed its FY 2003 AMP, which set maximum disposal goals for chromium materials in FY 2003 the same as those of 2002, 136,000 t of chromium ferroalloys, 90,700 t of chemical-grade chromite ore (or remaining inventory), 90,700 t of metallurgical-grade chromite ore (or remaining inventory), 90,700 t of refractory-grade chromite ore, and 454 t of chromium metal. The DNSC reported the sale of 90,718 t of refractory-grade chromite ore, 13,518 t of high-carbon ferrochromium, 9,601 t of ferrochromium silicon, and 6,261 t of low-carbon ferrochromium in FY 2002 (Defense National Stockpile Center, 2002a, b; U.S. Department of Defense, 2002, p. 6, 9).

The DNSC announced the sale of 90,700 t of refractory-grade chromite ore in January, exhausting the inventory; 10,900 t of low-carbon ferrochromium (6,260 t in February, 454 t and 1,814 t in August, 980 t in October, and 1,360 t in December); 6,940 t of ferrochromium silicon (3,080 t in February and 3,860 t in April); and 23,000 t of high-carbon ferrochromium (3,180 t and 9,072 t in August, 7,711 t in October, and 2,990 t in December) (Defense National Stockpile Center, 2002c-j).

The EPA announced in February that it reached a voluntary agreement with the treated-wood industry to discontinue the use of chromated copper arsenate (CCA) as a preservative treatment for wood that is to be used in a residential application (U.S. Environmental Protection Agency, 2002, 2002§[1]). The EPA planned to ban such use in 2004 under the Federal Insecticide, Fungicide, and Rodenticide Act.

The U.S. Department of Transportation reported the results of a study to estimate the economic impact of metallic corrosion to the U.S. economy and to identify national strategies to minimize that impact (Koch and others, 2002; U.S. Department of Transportation, Federal Highway Commission, 2002). Historical studies indicated that the cost of corrosion ranged from 1% to 5% of gross national product. The cost of corrosion to the United States in 1998 was estimated using two methods—by the cost of methods and services

[1]References that include a section mark (§) are found in the Internet References Cited section.

consumed as a result of corrosion and by the cost to industry sectors affected by corrosion. The direct cost of corrosion on the U.S. economy in 1998 was estimated to be $276 million, or 3.1% of the gross domestic product in that year. The report recommended greater awareness of the problem. Increased emphasis on corrosion mitigation is likely to increase the use of stainless steel, a corrosion-resistant material.

The U.S. Department of Labor regulates chromium in the workplace. The OSHA announced plans to go forward with proposed rulemaking on occupational exposure to hexavalent chromium [Cr(VI)] based on a request in 1993 by the Oil, Chemical and Atomic Workers Union and Public Citizen Health Research Group petition to lower the exposure limit (U.S. Department of Labor Occupation Safety Health Administration, 2002). OSHA's current permissible exposure limits (PELs) for chromic acid and chromates are reported in table Z-2 (29 CFR §1910.1000), which specifies a ceiling limit of 100 micrograms per cubic meter of air for all forms of hexavalent chromium, measured as Cr(VI) and reported as chromium oxide (CrO_3). The entry has remained unchanged since published in 1971. OSHA's interpretation is that the PEL for Cr(VI) in general industry is a ceiling value of 100 micrograms per cubic meter of air, measured as Cr(VI) and reported as CrO_3, as it is published. In the construction industry, the PEL is micrograms per cubic meter as an 8-hour, time-weighted-average.

Production

The major marketplace chromium materials are chromite ore and chromium chemicals, ferroalloys, and metal. In 2002, the United States produced chromium ferroalloys, metal, and chemicals, but no chromite ore. The United States is a major world producer of chromium metal and chemicals and of stainless steel. Chromite-containing refractory production decreased, and consolidation of the U.S. refractory industry in general continued. Domestic data for chromium materials are developed by the USGS by means of the monthly "Chromite Ores and Chromium Products" and "Consolidated Consumers" consumer surveys.

North American Stainless (NAS) added a melt shop to its production facilities at Ghent, OH. NAS reported a stainless steel production capacity of 800,000 metric tons per year (t/yr). With the addition of this melt shop, NAS joined AK-Steel, Allegheny Technologies, and J&L Specialty Steel as a major U.S. stainless steel producer (Platts Metals Week, 2002b). The NAS expansion was carried out against a background of consolidation in the steel industry (Platts Metals Week, 2002c). Stainless steel production accounts for about 2% of U.S. steel production.

The rationalization of the U.S. chromium chemical industry has been completed. Since 1967, when five chromium chemical plants owned by four companies consumed chromite ore to produce sodium dichromate in the United States, the number of such U.S. chromium chemical plants has been declining, while chromium chemical production has been slowly increasing. In 1986, the two currently producing chromium chemical plants became the last two such plants in the United States. Elementis Chromium LP (a subsidiary of Elementis plc of the United Kingdom) and Occidental Chemicals Corp. (OxyChem) (a subsidiary of Occidental Petroleum Company), operators of the two sodium-dichromate-producing plants in the United States, made an agreement whereby Elementis acquired OxyChem's chromium chemical plant at Castle Haynes, NC, where Elementis continued to produce sodium dichromate and chromic acid. Elementis was to eliminate its production of those chromium chemicals at its Corpus Christi, TX, plant, leaving the Corpus Christi plant to produce downstream chromium chemical products. The Castle Haynes plant would then be left as the only sodium-dichromate-producing chemical plant in the United States (Elementis plc, 2002a, b).

Health and Nutrition.—Huvinen (2002) described the occupational exposure to chromium and its long-term health effects in stainless steel production. Workers involved in chromite ore mine, ferrochromium, and stainless steel production environments were studied. While production workers were exposed to chromium, the observed health effects were minimal. The author concluded that it is technically and economically possible to achieve low exposure levels in the stainless steel production chain with no adverse health effects.

Environment

James (2002) discussed the mobility and bioavailability of chromium in soils and natural waters. He found that the trivalent form of chromium [Cr(III)] is less mobile, soluble, and toxic than Cr(VI). Cr(III) solubility is low and is dependent on pH. Soil contaminated with Cr(VI) can be cleaned up by converting the Cr(VI) to Cr(III). The conversion can be done using microorganisms or by manipulating the chemical environment. The oxidation state of chromium in natural waters and soils [Cr(III) and Cr(VI)] and the interconversion between the two are important factors in understanding the mobility, toxicity, bioavailability, and remediation of environments enriched with chromium-containing wastes.

Chromium is a micronutrient that improves the efficiency of insulin in individuals with impaired glucose tolerance. The Institute of Medicine (IOM) reported on the dietary reference intake (DRI) values for chromium based on the diets of healthy Americans and Canadians. DRI values comprise recommended daily allowance (RDA), adequate intake (AI), tolerable upper intake level (UL), and estimated average requirement. Life stage and gender affect the DRI. The IOM found that there were inadequate data to set an RDA; however, they could set an AI based on the average unit chromium content of balanced diets and balanced diet intakes as reported by the Third National Health and Nutrition Examination Survey, 1988-1994. Data for chromium are not sufficient to develop a UL, the highest level of intake that is likely to pose no risk, suggesting the need for caution in consuming amounts greater than recommended intakes. Chromium chemical speciation (the kind of chemical species in which chromium appears) and the route of exposure are important factors in chromium toxicity. Inhaled, Cr(VI) is carcinogenic. Chromium in food appears universally as Cr(III) and is nontoxic (Institute of Medicine, 2001, p. 36, 197-223).

Chromium is found in stainless steel welding fumes. The amount depends on the welding method and materials used. Cunat (2002) found that most arc welding processes create a fume containing predominantly Cr(III) and Cr(VI) present in only small proportions; however, some arc welding processes did not generate significant amounts of chromium-containing fume. For those arc-welding processes for which chromium containing fume is generated, efficient fume extraction is possible.

Antony and others (2001) investigated the recovery of chromium as sodium chromate from chromite ore processing residue (COPR), a material that results from the production of sodium chromate by the roasting of soda ash with chromite ore. Typical chromium recovery by this process is 85%, leaving 15% in the residue. The authors investigated the kinetics of extracting chromium from COPR using the soda-ash roasting process under oxidizing conditions. They also examined the dissolution of Cr(III) from COPR through an acidic aqueous phase. They obtained a maximum recovery of chromium from COPR of 83%.

Based on the demonstrated effectiveness of using iron to convert Cr(VI) to Cr(III), Singh and Singh (2001) employed iron-containing industrial waste materials to treat Cr(VI)-containing waste materials. Singh and Singh found that sludge from the effluent treatment plant of a steel-tube-making plant and red mud discharged after reclamation of bauxite ore in the aluminum industry were effective at converting Cr(VI) to Cr(III) as measured by the toxicity characteristic leaching procedure.

Consumption

The domestic chemical and refractory industries consumed chromite ore and concentrate in 2002. Chromium has a wide range of uses in the chemical, metallurgical, and refractory industries. The chemical industry consumed chromite for the manufacture of sodium dichromate, chromic acid, and other chromium chemicals and pigments. Sodium dichromate is the material from which a wide range of chromium chemicals is made. Chromite-containing refractory bricks were used to line metallurgical furnaces. Chromite sand was used as refractory sand in the casting industry. Ferrochromium was consumed to make chromium metal and special grades of ferrochromium. In the metallurgical industry, the principal use of chromium was in production of stainless steel. Other important uses for chromium include the production of ferrous and nonferrous alloys.

Stocks

Consumer stocks of ferroalloys, metal, and other chromium materials contained 8,335 t of chromium at yearend 2002. At the 2002 annual rate of chromium consumption, these consumer stocks represented a 6-day supply of chromium. The DOD managed the National Defense Stockpile through the DLA. Government inventories declined because the DLA disposed of stocks.

Prices

Chromium materials are not openly traded. Purchase contracts are confidential information between buyer and seller; however, trade journals report composite prices based on interviews with buyers and sellers, and traders declare the value of materials they import or export. Thus, industry publications and U.S. trade statistics are sources of chromium material prices and values, respectively.

Foreign Trade

Chromium material exports from and imports to the United States included chromite ore and chromium chemicals, ferroalloys, metal, and pigments. In 2002, the value of foreign trade of these chromium materials was $68 million for exports and $226 million for imports. Compared with that of 2001, the value of exports dropped by 24%, while that of imports dropped by 7%. Compared with that of 2001, the gross mass of exports dropped by 40%, while that of imports dropped by 1.5%.

World Review

Industry Structure.—The chromium industry comprises chromite ore, chromium chemicals and metal, ferrochromium, stainless steel, and chromite refractory producers. Several trends are taking place simultaneously in the chromium industry. Chromite chemical production has been growing slowly, while the industry eliminates excess capacity, concentrating on production and growth in the surviving plants. Chromite refractory use has been declining; however, foundry use has been growing slowly. Chromite ore production is moving from independent producers to vertically integrated producers. In other words, chromite ore mines tend now to be owned and operated by ferrochromium or chromium chemical producers. This trend is associated with the migration of ferrochromium production capacity from stainless-steel-producing countries to chromite-ore-producing countries. While ferrochromium production capacity was rationalized in historically producing countries, which usually have been stainless-steel-producing countries, new furnaces or plants were constructed in chromite-ore-producing areas. The electrical power and production capacities of submerged-arc electric furnaces used to produce ferrochromium have been increasing. Production process improvements, such as agglomeration of chromite ore, preheating and prereduction of furnace feed, and closed furnace technology, have been retrofitted at major producer plants and are being incorporated into newly constructed plants. When ferrochromium plants started to be built, furnaces rated in the low kilovoltampere range were common. Furnaces built recently have an electrical capacity in the tens of megavoltamperes (MVA). Since the introduction of post-melting refining processes in the steel industry after 1960, there has been a shift in production from low-carbon ferrochromium to high-carbon ferrochromium. After years of ferrochromium production, slag stockpiles have built up. Recently developed processes efficiently recover ferrochromium from that slag. These processes have been or are being installed at plant sites. In South Africa, the major chromite-ore- and ferrochromium-producing country, two trends are emerging—ferrochromium plants are being developed in the western belt of the Bushveld Complex and ferrochromium production processes are being designed to accommodate chromite ore byproduct from platinum operations.

Capacity.—Rated capacity is defined as the maximum quantity of product that can be produced in a period of time at a normally sustainable long-term operating rate, based on the physical equipment of the plant and given acceptable routine operating procedures involving labor, energy, materials, and maintenance. Capacity includes both operating plants and plants temporarily closed that, in the judgment of the author, can be brought into production within a short period of time with minimum capital expenditure. Because not all countries or producers make information about production capacity available, historical chromium trade data have been used to estimate production capacity. Production capacity changes result from both facility changes and knowledge about facilities. Production capacities have been rated for the chromite ore, chromium chemical, chromium metal, ferrochromium, and stainless steel industries.

Reserves.—The United States has no chromite ore reserves. However, the United States has a reserve base and resources that could be exploited. The U.S. reserve base is estimated to be about 10 million metric tons (Mt) of chromium. World reserves are about 3.6 billion tons (Gt) of chromium and the world reserve base is about 7.5 Gt. More than 80% of world reserves and more than 70% of the world reserve base are in South Africa. The USGS reports reserves and reserve base information annually in Mineral Commodity Summaries.

Production.—World chromite ore production in 2002 was about 13 Mt, of which about 90% was produced for the metallurgical industry; 1%, for the refractory industry; 6%, for the chemical industry; and 3%, for the foundry industry (International Chromium Development Association, 2003, p. 1). World ferrochromium production in 2002 was estimated to be about 5 Mt. World production of ferrochromium silicon is small compared with that of ferrochromium.

Production of chromite ore, ferrochromium, and stainless steel all declined from 2000 to 2001, then increased from 2001 to 2002. In 2000, excess stocks resulted in major producers closing furnaces in an effort to bring production in balance with demand. The effect was mitigated by reduced stainless steel production, causing prices to decline. Prices weakened throughout 2001. The weakening of the South African rand (R) relative to the U.S. dollar further lowered prices. A strengthening rand decreased ferrochromium producer stocks, and strengthening demand resulting from increased stainless steel production caused the price of ferrochromium to increase in 2002, and furnaces were restarted.

In addition to the countries listed, Spain and Taiwan produced stainless steel in 2002.

European Union.—With major stainless-steel-producing plants in Belgium, Finland, France, Germany, Italy, Spain, Sweden, and the United Kingdom, the European Union accounted for about 50% of world stainless steel production.

Australia.—Pilbara Chromite Pty. Ltd. (a division of Consolidated Minerals Limited) developed chromite ore reserves at its Coobina Chromite Project, about 80 kilometers (km) southeast of Newman, Western Australia. Reserves were estimated to exceed 1.6 Mt of chromite ore graded at 42% Cr_2O_3 to a depth of 30 meters (m). The chromite ore was found in 150 massive lenses. The chromite ore was mined by hydraulic excavator and transported by dump trucks. Pilbara stockpiles its chromite ore at Port Hedland, from where it is shipped. Consolidated started shipping chromite ore in February and planned to reach a production rate of 250,000 t/yr by surface mining from 1.96 Mt of reserves measured to a depth of 30 m. Consolidated planned to increase production to 500,000 t/yr and to develop a smelter to process its chromite ore (Consolidated Minerals, Ltd., 2003§).

Belgium.—UGINE & ALZ Belgium NV (a subsidiary of Arcelor) produced stainless steel at Genz.

Brazil.—Brazil produced chromite ore, ferrochromium, and stainless steel. In 2001, Brazil produced 409,000 t of chromite ore (42.6% Cr_2O_3), exported 78,500 t (38,400 t of Cr_2O_3-content), and imported 10,100 t (4,600 t of Cr_2O_3-content). Brazil produced chromium from a chromite ore reserve containing about 3 Mt of chromium. In 2001, Brazil produced 110,462 t of chromium ferroalloys, of which 97,100 t was high-carbon ferrochromium, 7,500 t was low-carbon ferrochromium, and the remainder was ferrochromium-silicon. Brazil imported 7,173 t of ferrochromium and exported 144 t (Gonçalves, 2002§). Based on production of chromite ore and trade of chromite ore and chromium ferroalloys, Brazilian chromium apparent consumption in 2001 was 113 t. Brazilian ferrochromium production in 2001 was limited by electrical power rationing that resulted from drought conditions.

Canada.—Allican Resources planned to construct a low-carbon ferrochromium smelter in the Gaspé region of Quebec. The plant was planned to have production capacity of 20,000 t/yr, power rating of 30 megawatts (MW), and a cost of Can$100 million. Products planned included ferrochromium containing 0.015% carbon, 0.05% carbon, or 0.10% carbon (Ryan's Notes, 2002).

China.—China produced chromite ore, chromium chemicals, ferrochromium, and stainless steel. China's chromite ore production was inadequate to meet domestic demand, so it imported ore.

China reported its national chromium-material trade statistics for 2002. Chromite ore imports were 1,140,000 t in 2002 and 1,090,000 t in 2001. Ferrochromium exports were 51,951 t in 2002 and 89,656 t in 2001. Ferrochromium imports were 71,642 t in 2002 and 36,000 t in 2001. China did not report its chromite ore production; however, it was estimated to have been 113,000 t in 2002 and 113,000 t in 2001. Based on this reported trade and estimated production, apparent consumption of chromium was 390,000 t in 2002 and 326,000 t in 2001 (TEX Report, 2002a; Paxton, 2003).

The Hunan Ferroalloys Group produced ferrochromium and chromium metal. Northwest Ferroalloys, Gansu Province, produced ferrochromium.

Croatia.—The Government of Croatia sold the Dalmacija ferrochromium smelter. At one time, the smelter had ferrochromium production capacity of 100,000 t/yr. It was not expected to produce any more ferrochromium.

Finland.—Finland produced chromite ore, ferrochromium, and stainless steel. AvestaPolarit produced stainless steel, and AvestaPolarit Chrome produced chromite ore and ferrochromium as part of a vertically integrated company structure within Outokumpu Oy, which included an integrated mine-smelter-steel works in Kemi and Tornio, Finland. The Kemi Mine produced 566,000 t of chromite concentrate from 1.2 Mt of ore excavated in 2002 (575,100 t of chromite concentrate from 1.2 Mt of ore excavated in 2001). Production of chromite ore was from a proven reserve of 51 Mt of ore with an average grade of 25% Cr_2O_3. The Kemi Mine continued to develop underground chromite ore reserves. AvestaPolarit reported production of 248,000 t of ferrochromium in 2002 and 236,000 t in 2001. Outokumpu reported that electricity accounted for more than one-third of its variable ferrochromium production cost. In 2002, AvestaPolarit commissioned new stainless steel production capacity at its Tornio plant by adding a new melt shop. The company planned to increase its stainless steel melting capacity to 1.65 Mt of slabs by 2004 from 650,000 t of slabs in 2002.

France.—France produced chromium metal and stainless steel.

Germany.—Germany produced chromium metal, ferrochromium, and stainless steel.

India.—India produced chromite ore, ferrochromium, stainless steel, and chromium chemicals. India reported that 20 mines produced 1,810,920 t of chromite ore in FY 2001-02 (April 2, 2001, through March 31, 2002) from a chromite ore recoverable reserve of 97.076 Mt (Indian Bureau of Mines, 2003§). India reported that 20 mines produced 1,951,649 t of chromite ore from a recoverable reserve of 86.23 Mt, 97% of which was in Orissa, in FY 2000-01 compared with production of 1,737,985 t in FY 1999-2000. For FY 1999-2000, India reported chromite ore exports of 714,448 t and imports of 6,886 t as well as imports of 116 t of chromium metal and scrap. India reported that seven plants produced 315,002 t of ferrochromium (ferrochrome plus charge chrome) in FY 2000-01 compared with production of 273,665 t in 1999-2000 fiscal year. For FY 1999-2000, India reported ferrochromium exports of 85,316 t and imports of 73,000 t (Indian Bureau of Mines, 2002a, b). Based on the chromite ore production and chromite ore and ferrochromium trade, Indian apparent chromium consumption in FY 1999-2000 was 267,000 t compared with 220,000 t in FY 1998-99.

Jindal Strips Ltd., a stainless steel and ferrochromium producer, planned to expand its stainless steel production capacity to 500,000 t/yr by 2004. Part of the expansion included Jindal entering the chromite ore mining business (Platts Metals Week, 2002a).

The Government of Orissa planned to develop the Tangarpada mines, 550 hectares in the Sukinda area containing 20 Mt of chromite ore reserves. Orissa selected Jindal Strips (89%) and Industrial Development Corp. of Orissa Ltd. (IDC) (11%) to develop the resources in a joint venture. The Government owned IDC and planned to privatize it. IDC operated a ferrochromium plant at Jajpur Road with high-carbon ferrochromium production capacity of 15,000 t/yr and held mining rights for chromite ore at the Tailangi mines (Lobo, 2003).

The IMFA Group reported that profitability returned to its subsidiary Indian Charge Chrome Ltd. (ICCL), which operated a charge chrome plant and captive powerplant (108 MW) at Choudwar, Orissa. ICCL built a large debt resulting from declining ferrochromium prices, the lack of dependable chromite ore supply, and a weakening rupee relative to the U.S. dollar, the currency in which it borrowed from banks. With the acquisition of a captive chromite ore supply and the price of ferrochromium increasing, ICCL planned to restructure its debt (IMFA Group, 2003§).

Orissa Mining Corp. (OMC) (wholly owned by the Government of Orissa) reported mining chromite ore from a reserve of 28.2 Mt from about 11 properties covering 5,800 hectares in the Jajpur District, Orissa. OMC operated the Bangur, Kaliapani, Kathal, and Sukrangi Mines, of which Kaliapani was the largest. OMC also operated a beneficiation plant at Kaliapani with output capacity of 84,000 t/yr of chromite concentrate (Orissa Mining Corp., undated§).

Italy.—Acciai Speciali Terni produced stainless steel at Terni, Umbria.

Japan.—Japan produced chromium chemicals, ferrochromium, and stainless steel. In 2002, Japan imported 727,385 t of high-carbon and 55,949 t of low-carbon ferrochromium; 354,928 t of chromite ore; 2,812 t of ferrochromium silicon; and 2,922 t of chromium metal. Japan produced 87,653 t of high-carbon and 4,380 t of low-carbon ferrochromium. Stainless steel production was 3.4517 Mt. Ferrochromium net imports represented 89% of market share. Japan exported 1,362 t of ferrochromium and 1.5245 Mt of stainless steel. Japan imported 131,411 t of stainless steel scrap and exported 121,584 t. Stainless steel net exports were 42% of stainless steel production (TEX Report, 2003a-i). Based on chromite ore, ferrochromium, chromium metal, and stainless steel scrap trade, chromium apparent consumption in Japan was 542,000 t in 2002.

Nippon Denko Co., Ltd. produced ferrochromium at a plant in Toyama; NKK Materials (NKK), at a plant in Toyama; and Shunan Denko, at a plant in Shunan. All produced high-carbon ferrochromium; however, only NKK produced low-carbon ferrochromium. Showa Denko K.K. planned to dissolve Shunan Denko K.K. (a joint venture with Nisshin Steel Co., Ltd. and Tokuyama Corporation). The Shunan plant has supplied molten ferrochromium to Nisshin Steel since 1968.

Nippon Denko planned to expand its chromium chemical business. Nippon Denko estimated the Japanese chromic acid consumption rate to have been 9,000 t/yr, of which 6,000 t was consumed in plating products and 3,000 t was available for recycling. Of the 3,000 t available for recycling, only 500 t is currently being recovered and 2,500 t is disposed with post plating sludge. Nippon Denko currently handles about one-half of the recovered chromium and planned to address recovery of that which is available for recycling but not currently recovered (Watanabe, 2003§).

Kazakhstan.—Kazakhstan produced chromite ore, chromium chemicals, chromium metal, and ferrochromium.

Norway.—Elkem stopped production of ferrochromium at Rana and put the property up for sale.

Russia.—Russia produced chromite ore, chromium chemicals, chromium metal, and ferrochromium. Polema Corp. planned to build a plant to produce chromium metal from chromic acid in Pervouralsk, Sverdlovsk region in cooperation with Russian Chrome 1915, a chromic acid producer in Pervouralsk. The plant was planned to be operational in 2003, with chromium metal production capacity of 1,000 t/yr.

South Africa.—South Africa produced chromite ore, chromium chemicals, ferrochromium, and stainless steel. The South African Minerals Bureau reported that, from a reserve base of 5,500 Mt of chromite ore in 2001, South Africa produced 5.502 Mt of chromite ore from which it produced 2.574 Mt of ferrochromium and other products. South Africa exported 931,000 t of chromite ore and 1.976 Mt of ferrochromium in 2001 (Armitage, 2002). Based on chromite ore production and chromite ore and ferrochromium trade, South African chromium apparent consumption was 512,000 t of contained chromium in 2000. The Minerals Bureau reported chromite ore production in 2002 of 6,435,746 t and sales of 5,951,480 t. Sales accounted for 82% of production, with domestic sales accounting for 89% of sales (South African Minerals Bureau, 2003). Based on chromite ore production and trade and ferrochromium trade, South African chromium apparent consumption was 289,000 t in 2001.

The South African rand declined in value relative to the U.S. dollar to R8.5755 per $1.00 in December from R12.3772 per $1.00 in January (Pacific Exchange Rate Service, 2003§). This change in exchange rate was partly responsible for the increased price of chromium materials.

South Africa passed the Mineral and Petroleum Resources Development Act that required the empowerment of historically disadvantaged South Africans (HDSAs). The Act requires the South African mining industry to develop and implement business plans that address the Government's goal of 15% ownership in 5 years and 26% in 10 years by HDSAs. The plan had the support of the Government, labor, and industry.

Tata Iron and Steel Co., Ltd. (India) planned to build a ferrochromium plant at Richards Bay, a port city. Tata is a major chromite ore producer in India and produces ferrochromium there, too. Owing to the high cost of electricity in India, the cost of ferrochromium production in India exceeded that of South Africa. As a result, Tata elected to produce ferrochromium in South Africa using chromite ore from India. At a cost of $62 million, the company planned to build the plant using Outokumpu technology to produce ferrochromium from one closed furnace having production capacity of 120,000 t/yr and electrical capacity of 57 MVA. Tata planned a second furnace to double production capacity. Construction was expected to begin in 2003; production, in 2005.

Transvaal Ferrochrome proposed construction of a ferrochromium plant in association with Buffelsfontien Mine, which Transvaal Ferrochrome planned to acquire and develop as part of the project. Transvaal Ferrochrome planned to obtain financing through the Australian stock exchange in 2003.

In 2002, Xstrata S.A. (Pty.) Ltd. (Xstrata) produced 2.929 Mt of chromite ore, run of mine, from a capacity of 4.44 million metric tons per year (Mt/yr) from three mines and 957,500 t of ferrochromium compared with 860,600 t of ferrochromium from a capacity of 1.3 Mt/yr from four plants in 2001. Xstrata's Kroondal Mine produced 1.33 Mt of chromite from a production capacity of 1.92 Mt/yr, Waterval produced 453,000 t from a production capacity of 1.2 Mt/yr, and Thorncliffe Mine produced 1.146 Mt from a production capacity of 1.32 Mt/yr. Xstrata produced ferrochromium at plants in Lydenburg, Marikana, and Rustenburg. Xstrata reported chromite ore reserves of 52.106 Mt (Xstrata, 2002§).

Samancor Chrome [owned by BHP Billiton (60%) and Anglo American Corp. of S.A.(40%)] produced 2.640 Mt of chromite ore and 892,000 t of ferrochromium in 2002 compared with 2.577 Mt of chromite ore and 799,000 t of ferrochromium in 2001 (BHP Billiton, 2003§). Samancor reported proven plus probable chromite ore reserves of 20.7 Mt graded at 42.3% Cr_2O_3 (BHP Billiton, 2002§).

Hernic (Pty.) Ltd. produced chromite ore and ferrochromium at Brits, North-West Province. Hernic started production in 1996 with ferrochromium production capacity of 130,000 t/yr from two 37-MVA semiclosed furnaces. Hernic doubled its production capacity in 1999 with the addition of a 54-MVA closed furnace, which pelletized and preheated the furnace feed. Hernic restructured ownership to 53% by Mitsubishi Corp. (Japan), 25% by Industrial Development Corp., 14% by ELG Haniel, and 8% by management. Hernic planned to increase production capacity by adding another closed furnace and a pelletizing/preheating plant (McCulloch, 2002).

ASA Metals (Pty.) Ltd. produced chromite ore and ferrochromium at Burgersfort, North-West Province. ASA produced chromite ore at Dilokong Mine, which had a chromite ore production capacity of 400,000 t/yr from a reserve of 40 Mt. ASA is owned 60% by East Asia Metal (China) and 40% by Limpopo Development and Enterprises. ASA started production in 1999 with one 33-MVA furnace capable of producing 55,000 t/yr of ferrochromium that cost $20 million to construct. ASA planned to add a second 40-MVA furnace that would increase ferrochromium production capacity by 65,000 t/yr at about the same cost (Claasen, 2003§).

Feralloys Limited (owned by Assmang Ltd.) produced chromite ore at Dwarsrivier and ferrochromium at Machadodorp. Feralloys commissioned a fourth furnace and associated pelletizing and preheating line designed by Outokumpu built at a cost of about $40 million. The new furnace has an electrical power capacity of 54 MVA and a ferrochromium production capacity of 175,000 t/yr. The pelletizing operation is capable of turning out 350,000 t/yr of pellets. The smelter is supplied chromite ore by the Dwarsrivier chromite ore mine in Mpumalanga Province about 140 km from the plant. The Dwarsrivier Mine had a reserve of 20 Mt and reserve base of 100 Mt. The mine was designed to produce 1 Mt/yr, run of mine, which could be increased to 1.25 Mt/yr. The mine started operation in 2000 as an opencast mine; however, as mining continues, surface mining will shift to underground. It was developed at a cost of R190 million (about $23 million).

South African Chrome and Alloys Limited (SA Chrome) produced chromite ore and ferrochromium at Boshoek near Brits in North-West Province. The ferrochromium plant comprised two closed electric-arc furnaces with pelletizing and preheating process equipment and cost about $45 million to construct. The plant was built above 13.6 Mt of chromite ore reserves held by SA Chrome and adjacent to reserves held by the Bafokeng Nation, a coowner of SA Chrome. The Horizon Mine, which is 40 km from the plant, extracts chromite ore from the LG6 seam. The smelter uses a blend of LG6 and UG2 ore. Chromite ore recovered from platinum mining of the UG2 seam is available 8 km from the plant. The first furnace was started in June, the second, in July. The ownership structure of SA Chrome is as follows: Bafokeng Nation (35%), Industrial Development Corp. (24%), Bateman Titaco (5%), Outokumpu (3%), ThyssenKrupp Metallurgie GmbH (2%), and others (35%). The plant uses Outokumpu technology to pelletize, preheat, and smelt up to 520,000 t/yr of chromite ore in two 54-MVA furnaces with ferrochromium production capacity of 235,000 t/yr (Haase, 2002; Halwindi, 2002; Zhuwakinyu, 2002).

Columbus Stainless produced stainless steel in Middelburg, Mpumalanga Province. Columbus planned to increase stainless steel production capacity to about 750,000 t/yr from 350,000 t/yr.

Sweden.—Sweden produced ferrochromium and stainless steel. The Swedish Emergency Management Agency sold 6,529 t of ferrochromium that was held in the Swedish national stockpile.

Turkey.—Turkey produced chromite ore, chromium chemicals, and ferrochromium.

United Kingdom.—The United Kingdom produced chromium chemicals and metal and stainless steel.

Zimbabwe.—Zimbabwe produced chromite ore and ferrochromium. Zimbabwe Alloys Mines Limited reported putting its mine on care-and-maintenance status.

Current Research and Technology

Mineral Processing and Industrial Applications.—Industry conducts research to develop new, more efficient processes and to improve the efficiency of currently used processes. The Council for Mineral Technology (Mintek) of South Africa conducts Government-sponsored, commercially sponsored, and cosponsored research and development on chromite ore and ferrochromium.

Researchers at Mintek reviewed the flotation of chromite and applied it to upgrading chromium-contaminated ilmenite (Hayes and others, 2001). The authors concluded that, owing to the similar response of chromite and ilmenite, it will be necessary to find a specific activator for chromite and a specific depressant for ilmenite to separate the two minerals.

Reinke (2001) studied the reduction of chromite under conditions of controlled geometry and thermodynamics. Historical studies of chromite reduction used chromite ores, a material of variable grain sizes, shapes, and conditions. The author found reduction of chromite to be rate-limited by solid-state diffusion.

Technology.—Corrosion of metals results in a significant economic cost to society. (More information can be found in the "Legislation and Government Programs" section of this report). Stainless steel is called stainless because it does not corrode or stain perceptibly. The most common form of iron corrosion is rust. Stainless steel is an engineering alternative material to alloy steel that contains about 13% chromium and additions of other alloying elements. While resistant to rust and other forms of corrosion, common grades of stainless steel are susceptible to pitting corrosion in certain environments, namely wet salty environments. To counteract pitting corrosion, metallurgists increase chromium additions and add other alloying elements, such as molybdenum, and modify its processing, all of which increase cost. Ryan and others (2002) have identified the physical conditions that promote pitting corrosion as the reduction in chromium-to-iron ratio near manganese sulfide inclusions. Engineers may use this information as the basis for improving alloying or production technology that will result in the production of stainless steel with better material properties at a lower price.

Outlook

The outlook for chromium consumption in the United States and the rest of the world is about the same as that for stainless steel, which is the major end use for chromium worldwide. Thus, stainless steel industry performance largely determines chromium industry demand worldwide. (More information can be found in the "Current Research and Technology" section on stainless steel.)

The trend to supply chromium in the form of ferrochromium by countries that mine chromite ore is expected to continue. With new efficient ferrochromium production facilities and excess capacity in chromite-ore-producing countries, ferrochromium capacity and production are expected to diminish in countries that produce ferrochromium but not chromite ore, and in countries with small, less efficient producers. Further vertical integration of the chromium industry is expected as chromite-ore-producing countries expand ferrochromium or stainless steel production capacity.

Chromite Ore.—Chromite ore production capacity is in balance with average consumption. Consumption capacity by ferrochromium plants, however, exceeds production capacity, which can lead to short supply when demand surges, thus preventing ferrochromium producers from meeting surge demand. To improve chromite ore availability and to stabilize feed material price, ferrochromium producers invest in chromite-ore-producing mines. Indeed, most chromite ore is produced under vertically integrated mine-smelter or mine-plant ownership.

Chromium Chemicals.—In 2002, major producing countries where large plants (capacity in excess of 100,000 t/yr of sodium dichromate) operate included Kazakhstan, Russia, the United Kingdom, and the United States. Moderate-sized production facilities were located in China, Japan, Romania, South Africa, and Turkey. Small-scale local producers operated in China and India.

CCA has been a popular wood treatment chemical in the United States. Globally, CCA was the second largest market for chromic acid, the major product of sodium dichromate, accounting for about 78,400 t of chromic acid in 2000. It was estimated that the United States accounted for about one-half of the CCA market, of which about three-quarters was used to treat wood used in residential applications. U.S. manufacturers of treated wood planned to phase out the use of CCA by voluntary agreement with the EPA. That change in use caused the U.S. chromium chemical industry to reorganize. Worldwide, about 1 Mt/yr of chromite ore was consumed by the chemical industry to produce 692,000 t/yr of sodium dichromate. Sodium dichromate has been converted to chromic acid at the rate of 224,000 t/yr. Chromic acid has accounted for 32% of sodium dichromate demand; chromium sulfate, 30%; chromic oxide, 20%; and other chemicals, 18%. Chromic acid has been converted to CCA at the rate of 100,000 t/yr. CCA has accounted for 35% of chromic acid demand; metal finishing, 50%; magnetic media, 5%; and other uses, 10% (Industrial Minerals, 2002).

Chromium Metal.—Major chromium metal producers include Russia and the United States (by the electrolytic process) and China, France, Russia, and the United Kingdom (by the aluminothermic process). Chromium metal demand was estimated to be 19,500 t in 2002, down from about 21,000 t in 2001. Demand in 2003 was expected to decline. Chromium metal produced by aluminothermic reduction was estimated to have accounted for about 90% of production in 2002. Aluminothermically produced chromium metal accounted for 60% to 65% during the 1990s (TEX Report, 2002b; 2003j).

New uses are developing for chromium metal. Buchanan (2002) estimated world production of chromium metal in 2001 to be 30,000 t, of which 17% to 25% was produced by the electrolytic process. In the electronics industry, chromium is used in the manufacture of hard disks, TV flat panel displays, and liquid crystal displays.

Ferrochromium.—Ferrochromium production is electrical energy intensive. Charge-grade ferrochromium requires 2,900 to 4,100 kilowatthours of electrical energy per metric ton of product, with efficiency varying by ore grade, operating conditions, and production process. Thus, ferrochromium plant location reflects a cost balance between raw materials and electrical energy supply.

De Wet (2002) reported chromium industry trends to include continued growth in stainless steel production at the average rate of 5% per year, increased ferrochromium industry transparency, and production sensitivity to price. He noted that, historically, the ferrochromium industry has increased production capacity in advance of real demand, thereby eroding price. He reported that, in 2001, chromite ore consumption was distributed among the metallurgical (82%), chemical (10%), and refractory and foundry industries (8%). Of the 82% consumed in the metallurgical industry, 75% was used in the production of stainless steel, with the remaining 25% in the production of alloy and carbon steel among other alloys.

Jones (2002) reported ferrochromium price, supply, demand, balance, and capacity trends. Jones found that the price of ferrochromium entering 2002 was trending downward and was low compared with historical prices. He attributed the downward trend to producer inventory reduction and the depreciating value of the South African rand relative to the U.S. dollar. He identified stainless steel production as the major source of demand for ferrochromium.

Stainless Steel.—Stainless steel demand is expected to grow in the long term. Short-term demand fluctuations can exceed long-term demand growth.

Moll (2003) reported that stainless steel production grew at a rate of 6% per year from 1950 through 2002 and forecasted a growth rate of 5% per year to 2010. Moll's review of planned or proposed projects suggested that 8 to 15 Mt will be added to the current global stainless steel production capacity of 25 Mt by 2010.

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TABLE 1

SALIENT CHROMIUM STATISTICS[1]

(Metric tons of contained chromium unless otherwise specified)

		1998	1999	2000	2001	2002
World production:						
Chromite ore, mine[2]		4,120,000 [r]	4,300,000 [r]	4,430,000 [r]	3,670,000 [r]	4,060,000 [e]
Ferrochromium, smelter[3]		2,710,000	2,850,000	3,260,000	2,670,000	2,760,000 [e]
Stainless steel[4]		2,790,000 [r]	2,970,000	3,260,000 [r]	3,160,000 [r]	3,340,000 [e]
U.S. supply:						
Components of U.S. supply:						
Domestic mines		--	--	--	--	--
Secondary		104,000	118,000	139,000	122,000	139,000
Imports:						
Chromite ore		117,000	85,000	86,200	62,000	35,300
Chromium chemicals		9,070	10,400	12,500	12,800	17,400
Chromium ferroalloys		249,000	371,000	344,000	156,000	203,000
Chromium metal		9,520	9,030	9,930	8,190	7,430
Stocks, January 1:						
Government		1,020,000	928,000	909,000	825,000	705,000 [5]
Industry[6]		64,000	59,700	14,500	15,600	16,700
Total		1,570,000	1,580,000	1,520,000	1,200,000	1,120,000
Distribution of U.S. supply:						
Exports:						
Chromite ore		39,900	37,200	44,600	20,000	7,360
Chromium chemicals		17,500	17,300	16,400	13,200 [r]	10,500
Chromium ferroalloys and metal		5,000	5,790	25,400	9,840	10,800
Stocks, December 31:						
Government		928,000	909,000	825,000	816,000	604,000
Industry[6]		59,700	54,500	15,600	16,700 [r]	8,340
Total		1,050,000	1,020,000	927,000	875,000 [r]	641,000
Production, reported:[7]						
Chromium ferroalloy and metal net production:						
Gross weight		W	W	W	W	W
Chromium content		W	W	W	W	W
Net shipments		W	W	W	W	W
Consumption:						
Apparent		524,000	558,000	589,000	326,000 [r]	483,000
Reported:						
Chromite ore and concentrates, gross weight		269,000	W	W	W	W
Chromite ore average Cr_2O_3	percentage	45.4	45.0	44.8	45.0	45.4
Chromium ferroalloys, gross weight[8]		345,000	398,000	384,000	329,000 [r]	379,000
Chromium ferroalloys, contained chromium[8]		195,000	220,000	215,000	189,000 [r]	220,000
Chromium metal, gross weight		4,670	4,690	4,980	5,880	4,910
Stocks, December 31, gross weight:						
Government:						
Chromite ore		885,000	820,000	636,000	636,000 [e, 5]	204,000 [5]
Chromium ferroalloys		974,000	973,000	919,000	906,000 [e, 5]	763,000 [5]
Chromium metal		7,720	7,720	7,550	7,430 [e, 5]	7,220 [5]
Industry, producer[9]		W	W	W	W	W
Industry, consumer:						
Chromite ore[10]		159,000	130,000	W	W	W
Chromium ferroalloys[11]		17,300	24,900	26,400	W	7,760
Chromium metal		195	245	191	210	219
Prices, average annual:						
Chromite ore, gross weight[12]	dollars per metric ton	$68	$63	NA	NA	NA
Ferrochromium, chromium content[13]	dollars per pound	$0.467	$0.366	$0.414	$0.324	$0.317
Standard chromium metal, gross weight[14]	do.	$4.73	$4.43	$4.43	$4.24	NA
Vacuum chromium metal, gross weight[14]	do.	$5.38	$5.38	$5.42	$5.43	NA
Electrolytic chromium metal, gross weight[15]	do.	$4.50	$4.50	$4.50	$4.50	$4.50
Aluminothermic chromium metal, gross weight[16]	do.	$2.91	$2.50	$2.35	$2.08	$2.08
Value of trade:[17]						
Exports	thousands	$102,000	$92,500	$110,000	$89,400	$67,600
Imports	do.	$421,000	$420,000	$427,000	$239,000	$256,000
Net exports[18]	do.	-$319,000	-$327,000	-$317,000	-$149,000	-$188,000

See footnotes at end of table.

TABLE 1--Continued
SALIENT CHROMIUM STATISTICS[1]

(Metric tons of contained chromium unless otherwise specified)

		1998	1999	2000	2001	2002
Stainless steel, gross weight:						
Production[19]		2,010,000	2,190,000	2,190,000	1,820,000	2,190,000
Shipments[20]		1,850,000	1,890,000	1,930,000	1,670,000	1,720,000
Exports		206,000	216,000	264,000	249,000	273,000
Imports		862,000	941,000	989,000	761,000	752,000
Scrap:						
Receipts		610,000	694,000	817,000	720,000	815,000
Consumption		1,040,000	1,140,000	1,220,000	1,080,000	1,190,000
Exports		298,000	260,000	468,000	438,000	342,000
Imports		57,200	66,100	56,200	42,300	81,000
Value of trade:						
Exports	thousands	$622,000	$628,000	$782,000	$752,000	$742,000
Imports	do.	$1,680,000	$1,560,000	$2,010,000	$1,430,000	$1,350,000
Scrap exports	do.	$176,000	$151,000	$310,000	$270,000	$252,000
Scrap imports	do.	$21,600	$27,700	$35,500	$24,100	$49,400
Net exports[18, 21]	do.	-$903,000	-$811,000	-$955,000	-$433,000	-$405,000

[e]Estimated. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data. -- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Calculated assuming chromite ore to average 44% Cr_2O_3, which is 68.42% chromium.
[3]Calculated assuming chromium content of ferrochromium to average 57%.
[4]Calculated assuming chromium content of stainless steel to average 17%.
[5]In September 2001, the Defense National Stockpile Center discontinued the accounting systems used to generate stocks by commodity reported in this table. Estimated stocks for 2001 and reported stocks before 2001 used the previous accounting systems. Reported stocks for 2002 used the current accounting systems.
[6]Includes consumer stocks of chromium ferroalloys and metal and other chromium-containing materials. Also includes chromium chemical and refractory producer stocks of chromite ore before 2000.
[7]Includes chromium ferroalloys and metal and other chromium materials in the United States.
[8]Chromium ferroalloy and other chromium-containing materials excluding chromium metal.
[9]Chromium ferroalloy and metal producer stocks of chromium ferroalloys and metal.
[10]Chemical, chromium ferroalloy and metal, and refractory producer stocks of chromite ore.
[11]Consumer stocks of chromium ferroalloys and metal and other chromium-containing materials.
[12]Time-weighted average price of South African chromite ore, as reported in Platts Metals Week.
[13]Time-weighted average price of imported high-carbon chromium that contains 50% to 55% chromium, as reported in Platts Metals Week.
[14]Time-weighted average price of electrolytic chromium metal, as reported in American Metal Market, before 2002.
[15]Time-weighted average price of domestically produced electrolytic chromium metal as reported by Ryan's Notes.
[16]Time-weighted average price of imported aluminothermic chromium metal as reported by Ryan's Notes.
[17]Includes chromite ore and chromium ferroalloys, metal, and chemicals.
[18]Data indicate that imports are greater than exports.
[19]Data on stainless steel production from American Iron and Steel Institute annual reports and quarterly production of stainless and heat-resisting raw steel.
[20]Data on stainless steel shipments from American Iron and Steel Institute annual reports.
[21]Includes stainless steel and stainless steel scrap.

TABLE 2
PRINCIPAL U.S. PRODUCERS OF CHROMIUM PRODUCTS IN 2002, BY INDUSTRY

Industry and company	URL address	Plant
Metallurgical:		
Eramet Marietta Inc.	NA	Marietta, OH.
JMC (USA) Inc.	http://www.jmcusa.com	Research Triangle Park, NC.
Refractory, National Refractories and Minerals Corp.	http://www.nrmc.com	Columbiana, OH.
Chemical:		
Elementis Chromium LP	http://www.elementis.com	Corpus Christi, TX.
Occidental Chemical Corp.	http://www.oxychem.com	Castle Hayne, NC.

NA Not available.

TABLE 3

U.S. REPORTED CONSUMPTION AND STOCKS OF CHROMIUM PRODUCTS[1]

(Metric tons)

	2001		2002	
	Gross weight	Chromium content	Gross weight	Chromium content
Consumption by end use:				
Alloy uses:				
Iron alloys:				
Steel:				
Carbon steel	9,980 r	5,910 r	9,520	5,530
High-strength low-alloy steel	12,700 r	7,790 r	6,510	3,890
Stainless and heat-resisting steel	255,000	146,000	312,000	181,000
Full alloy steel	17,200 r	10,300 r	17,000	10,200
Electrical steel	W	W	W	W
Tool steel	5,640	3,390	5,040	3,010
Superalloys	10,400 r	8,130 r	8,570	6,720
Other alloys[2]	21,100	12,000	22,400	12,800
Other uses not reported above	W	W	W	W
Total	335,000 r	195,000 r	384,000	225,000
Consumption by material:				
Low-carbon ferrochromium	35,600	23,600	36,800	24,700
High-carbon ferrochromium	253,000 r	151,000 r	293,000	176,000
Ferrochromium silicon	38,200 r	14,000 r	47,100	18,300
Chromium metal	5,880	5,880	4,910	4,880
Chromite ore	1,020	332	1,530	474
Chromium-aluminum alloy	682	383	689	435
Other chromium materials	612	252	472	213
Total	335,000 r	195,000 r	384,000	225,000
Consumer stocks:				
Low-carbon and high-carbon ferrochromium	26,400	15,800	12,500	7,630
Ferrochromium silicon	1,340	491 r	982	382
Chromium metal	210	210	219	218
Chromite ore	66	22	72	22
Chromium-aluminum alloy	72	40	65	41
Other chromium materials	123	51	103	46
Total	28,200 r	16,700 r	13,900	8,340

[r]Revised. W Withheld to avoid disclosing company proprietary data; included in "Total."

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Includes cast irons, welding and alloy hard-facing rods and materials, wear- and corrosion-resistant alloys, and aluminum, copper, magnetic, nickel, and other alloys.

TABLE 4
U.S. GOVERNMENT STOCKPILE YEAREND INVENTORIES AND CHANGE
FOR CHROMIUM-CONTAINING MATERIALS[1, 2]

(Metric tons, gross weight)

	2002		Change	
Material	January 1	December 31	Quantity	Percentage[3]
Chromite ore:				
Chemical	192,000	78,300	-114,000	-59
Metallurgical	62,000	--	-62,000	-100
Refractory	202,000	126,000	-75,800	-38
Chromium ferroalloys:				
Ferrochromium-silicon	6,970	--	-6,970	-100
High-carbon ferrochromium	561,000	531,000	-30,200	-5
Low-carbon ferrochromium	243,000	232,000	-11,500	-5
Chromium metal	7,220	7,220	--	--

-- Zero.
[1]Data are rounded to no more than three significant digits.
[2]In September 2001, the Defense National Stockpile Center discontinued the accounting systems used to generate stocks by commodity reported in this table. An alternate accounting system was adopted to report stocks by commodity. These Government stocks are reported by the Defense National Stockpile Center in Inventory of Stockpile Materials R-1, which reports uncommitted inventory. Uncommitted inventory is that inventory for which there is no sales contract. Committed inventory is that inventory for which there is a sales contract; however, the material has not yet been shipped. For chromium materials, the R-1 report includes chromium materials that (1) meet specifications and are held in excess of goal and (2) do not meet specifications and are held in excess of goal. The R-1 report excludes chromium materials that are committed and awaiting shipment.
[3]Quantity change as a percentage of stocks on January 1, 2002.

Source: Defense Logistics Agency, Defense National Stockpile Center.

TABLE 5

TIME-VALUE RELATIONS FOR IMPORTS OF CHROMITE ORE, FERROCHROMIUM, AND CHROMIUM METAL [1, 2]

(Annual average value, dollars per metric ton)

	2001		2002	
Material	Contained chromium	Gross weight	Contained chromium	Gross weight
Chromite ore:				
Not more than 40% chromic oxide	1,910	471	833	195
More than 40%, but less than 46% chromic oxide	431 r	132 r	232	67
46% or more chromic oxide	176	58	182	58
Average[3]	187	61	191	60
Ferrochromium:				
Not more than 3% carbon:				
Not more than 0.5% carbon	2,180	1,490	1,550	1,030
More than 0.5%, but not more than 3% carbon	993	622	950	586
Average[3]	2,050	1,390	1,410	921
More than 3%, but not more than 4% carbon	1,500	1,020	(4)	(4)
More than 4% carbon	579	335	546	326
Grand average[3]	709	415	646	390
Chromium metal	XX	6,170	XX	5,770

[r]Revised. XX Not applicable.

[1]Based on customs value of chromium contained in imported material.

[2]Data are rounded to no more than three significant digits; may not add to totals shown.

[3]Mass-weighted average.

[4]No imports of medium-carbon (more than 3%, but not more than 4% carbon) ferrochromium were reported in 2002.

Source: U.S. Census Bureau.

TABLE 6
PRICE QUOTATIONS FOR CHROMIUM MATERIALS
AT BEGINNING AND END OF 2002

Material	January	December	Year average[1]
Cents per pound of chromium:			
High-carbon ferrochromium, imported:[2]			
50% to 55% chromium	28.25-29.00	34.00-36.00	31.68
60% to 65% chromium	27.00-29.00	33.50-36.00	31.88
Low-carbon ferrochromium, imported:[2]			
0.05% carbon	61-66	71-76	73
0.10% carbon	58-62	62-65	65
Cents per pound of product:			
Chromium metal, domestic:			
Electrolytic, standard[3]	380-400	NA	NA
Electrolytic, vacuum[3]	520-565	NA	NA
Electrolytic[4]	450	450	450
Chromium metal, imported:			
Aluminothermic[4]	200-210	195-205	208

NA Not available.
[1]Time-weighted average.
[2]Source: Platts Metals Week.
[3]Source: American Metal Market.
[4]Source: Ryan's Notes.

TABLE 7
U.S. EXPORTS OF CHROMIUM MATERIALS, BY TYPE[1]

HTS[2]	Type	2001 Quantity (kilograms)	2001 Value (thousands)	2002 Quantity (kilograms)	2002 Value (thousands)	Principal destinations, 2002
2610.00.0000	Chromite ore and concentrate, gross weight	61,000,000	$6,680	24,300,000	$4,070	Sweden (74%); Mexico (14%); Canada (11%).
	Metal and alloys:					
8112.20.0000	Chromium metal including waste and scrap, gross weight	1,040,000	10,700	XX	XX	
8112.21.0000	Unwrought chromium powders, gross weight	XX	XX	247,000	2,510	Canada (54%); Japan (21%); Belgium (7%); Germany (7%); China (2%); Mexico (2%); Netherlands (1%); United Kingdom (1%).
8112.22.0000	Chromium metal waste and scrap, gross weight	XX	XX	30,200	449	Austria (30%); Canada (26%); Japan (20%); Germany (14%); China (6%); Liechtenstein (2%); India (1%); Republic of Korea (1%).
8112.29.0000	Chromium metal other than unwrought powders and waste and scrap, gross weight	XX	XX	467,000	4,490	Japan (75%); Netherlands (15%); Peru (3%); Mexico (2%); Germany (1%); Singapore (1%).
	Total chromium metal, gross weight	1,040,000	10,700	745,000	7,450	
	Chromium ferroalloys:					
7202.41.0000	High-carbon ferrochromium, gross weight[3]	8,390,000	6,260	13,500,000	7,140	Switzerland (67%); Canada (20%); Mexico (11%); Brazil (2%).
7202.41.0000	High-carbon ferrochromium, contained weight[3]	3,380,000	XX	8,710,000	XX	
7202.49.0000	Low-carbon ferrochromium, gross weight[4]	7,880,000	6,160	2,070,000	2,640	Canada (54%); Mexico (23%); Netherlands (11%); Belgium (3%); United Kingdom (3%); China (2%); Sweden (2%).
7202.49.0000	Low-carbon ferrochromium, contained weight[4]	5,400,000	XX	1,250,000	XX	
7202.50.0000	Ferrochromium-silicon, gross weight	85,500	92	281,000	290	Canada (89%); Hong Kong (5%); Germany (3%); Mexico (3%).
7202.50.0000	Ferrochromium-silicon, contained weight	26,600	XX	97,000	XX	
	Total ferroalloys:					
	Gross weight	16,400,000	12,500	15,900,000	10,100	
	Contained weight	8,800,000	XX	10,100,000	XX	
	Chemicals, gross weight:					
	Chromium oxides:					
2819.10.0000	Chromium trioxide	10,700,000	26,600	8,380,000	15,700	Canada (34%); Mexico (11%); Republic of Korea (8%); Brazil (6%); Taiwan (6%); Australia (5%); Germany (5%); New Zealand (5%); Japan (4%); Hong Kong (3%); China (2%); Indonesia (2%); Malaysia (2%); Thailand (2%); Singapore (1%).
2819.90.0000	Other	2,730,000	10,300	2,410,000	7,660	Canada (51%); United Kingdom (10%); Spain (8%); Japan (6%); Taiwan (6%); China (4%); Australia (3%); Republic of Korea (2%); Philippines (2%); Thailand (2%); Germany (1%); Singapore (1%).
2833.23.0000	Chromium sulfates	13,100	200	93,400	365	Canada (87%); Chile (6%); United Kingdom (3%); Colombia (2%); Hong Kong (1%).
	Salts of oxometallic or peroxometallic acids:					
2841.20.0000	Zinc and lead chromate	158,000	416	125,000	389	Canada (79%); Taiwan (15%); Germany (2%); Mexico (2%).
2841.30.0000	Sodium dichromate	16,300,000	16,600	12,600,000	12,400	Canada (41%); Thailand (22%); Mexico (15%); Peru (5%); Colombia (3%); Taiwan (3%); Hong Kong (2%); Republic of Korea (2%); Phillipines (2%); Brazil (1%).
2841.40.0000	Potassium dichromate	18,600	44	XX	XX	
2841.50.0000	Other chromates and dichromates; peroxochromates:	562,000	1,650	XX	XX	
2841.50.1000	Potassium dichromate	XX	XX	25,800	46	Hong Kong (63%); Canada (32%); Finland (4%); Netherlands (1%).

See footnotes at end of table.

TABLE 7--Continued

U.S. EXPORTS OF CHROMIUM MATERIALS, BY TYPE[1]

HTS[2]	Type	2001 Quantity (kilograms)	2001 Value (thousands)	2002 Quantity (kilograms)	2002 Value (thousands)	Principal destinations, 2002
2841.50.0000	Other chromates and dichromates; peroxochromates--Continued:					
2841.50.9000	Other	XX	XX	516,000	1,750	Republic of Korea (51%); Malaysia (15%); China (8%); Canada (7%); Mexico (4%); Netherlands (4%); Costa Rica (3%); Venezuela (3%); Saudi Arabia (2%).
3206.20.0000	Pigments and preparations, gross weight	771,000	3,710	824,000	7,650	Canada (52%); Mexico (30%); China (2%); Switzerland (2%); Taiwan (2%); United Arab Emirates (2%); Singapore (1%).

XX Not applicable.

[1]Data are rounded to no more than three significant digits; may not add to totals shown. Revised as of March 3, 2004.

[2]Harmonized Tariff Schedule of the United States of America code.

[3]More than 4% carbon.

[4]Not more than 4% carbon.

Source: U.S. Census Bureau.

TABLE 8

U.S. IMPORTS FOR CONSUMPTION OF CHROMITE ORE, BY COUNTRY[1]

	Not more than 40% chrome oxide (Cr_2O_3) (HTS[2] 2610.00.0020)			More than 40%, but less than 46% Cr_2O_3 (HTS[2] 2610.00.0040)			46% or more Cr_2O_3 (HTS[2] 2610.00.0060)			Total		
Country	Gross weight (metric tons)	Cr_2O_3 content (metric tons)	Value[3] (thousands)	Gross weight (metric tons)	Cr_2O_3 content (metric tons)	Value[3] (thousands)	Gross weight (metric tons)	Cr_2O_3 content (metric tons)	Value[3] (thousands)	Gross weight (metric tons)	Cr_2O_3 content (metric tons)	Value[3] (thousands)
2001:												
Canada	1,600	575	$751	--	--	--	87	45	$52	1,680	620	$803
South Africa	--	--	--	105 r	47 r	$14 r	187,000 r	89,700 r	10,700 r	187,000	89,800	10,700
Turkey	--	--	--	--	--	--	306	168	70	306	168	70
Total	1,600	575	751	105 r	47 r	14 r	187,000 r	89,900 r	10,800 r	189,000	90,600	11,600
2002:												
Canada	38	13	15	--	--	--	--	--	--	38	13	15
Germany	--	--	--	--	--	--	18	9	5	18	9	5
Philippines	981	335	180	--	--	--	--	--	--	981	335	180
South Africa	63	22	16	10,600	4,470	710	100,000	46,700	5,800	111,000	51,200	6,530
Total	1,080	370	211	10,600	4,470	710	100,000	46,700	5,810	112,000	51,600	6,730

r Revised. -- Zero.

1 Data are rounded to no more than three significant digits; may not add to totals shown.

2 Harmonized Tariff Schedule of the United States code.

3 Customs import value generally represents a value in the foreign country and therefore excludes U.S. import duties, freight, insurance, and other charges incurred in bringing the merchandise into the United States.

Source: U.S. Census Bureau.

TABLE 9

U.S. IMPORTS FOR CONSUMPTION OF FERROCHROMIUM, BY COUNTRY[1]

	Not more than 0.5% carbon (HTS[2] 7202.49.5090)			More than 0.5% carbon, but not more than 3% carbon (HTS[2] 7202.49.5010)			More than 3% carbon, but not more than 4% carbon (HTS[2] 7202.49.1000)			More than 4% carbon (HTS[2] 7202.41.0000)			Total (all grades)		
Country	Gross weight (metric tons)	Chromium content (metric tons)	Value (thou-sands)	Gross weight (metric tons)	Chromium content (metric tons)	Value (thou-sands)	Gross weight (metric tons)	Chromium content (metric tons)	Value (thou-sands)	Gross weight (metric tons)	Chromium content (metric tons)	Value (thou-sands)	Gross weight (metric tons)	Chromium content (metric tons)	Value (thou-sands)
2001:															
Brazil	20	12	$45	--	--	--	--	--	--	--	--	--	20	12	$45
Canada	4	3	13	--	--	--	--	--	--	--	--	--	4	3	13
China	20	14	25	--	--	--	--	--	--	103	68	$78	123	81	103
France	3	2	4	--	--	--	--	--	--	--	--	--	3	2	4
Germany	7,240	5,090	14,200	--	--	--	--	--	--	--	--	--	7,240	5,090	14,200
Japan	2,520	1,600	5,350	--	--	--	--	--	--	20	14	42	2,540	1,620	5,390
Kazakhstan	--	--		500	345	$275	--	--	--	61,400	42,100	21,100	61,900	42,500	21,400
Mexico	19	12	40	--	--	--	--	--	--	--	--	--	19	12	40
Russia	6,440	4,450	5,100	--	--	--	20	13	$20	20	14	12	6,480	4,480	5,140
South Africa	933	582	919	1,720	1,040	1,000	--	--	--	138,000	72,100	42,900	140,000	73,700	44,900
Sweden	38	28	72	76	55	152	--	--	--	38	28	78	152	110	302
United Kingdom	--	--	--	--	--	--	--	--	--	20	14	20	20	14	20
Zimbabwe	--	--	--	--	--	--	--	--	--	37,200	22,400	14,900	37,200	22,400	14,900
Total	17,200	11,800	25,700	2,290	1,440	1,430	20	13	20	236,000	137,000	79,200	256,000	150,000	106,000
2002:															
China	98	65	138	--	--	--	--	--	--	82	54	94	180	119	232
France	4	3	5	--	--	--	--	--	--	--	--	--	4	3	5
Germany	4,180	2,920	7,710	--	--	--	--	--	--	6,120	4,260	2,850	10,300	7,180	10,600
India	--	--	--	--	--	--	--	--	--	89	57	46	89	57	46
Japan	1,040	726	2,160	--	--	--	--	--	--	--	--	--	1,040	726	2,160
Kazakhstan	2,600	1,820	1,950	1,960	1,360	1,370	--	--	--	109,000	75,500	39,900	114,000	78,700	43,200
Russia	12,300	8,420	11,600	991	695	884	--	--	--	2,710	1,870	2,450	16,100	11,000	14,900
South Africa	5,040	2,820	2,410	5,090	2,900	2,450	--	--	--	132,000	68,100	36,600	143,000	73,800	41,400
Turkey	261	189	289	--	--	--	--	--	--	6,000	3,570	1,840	6,260	3,760	2,130
Venezuela	--	--	--	--	--	--	--	--	--	20	14	12	20	14	12
Zimbabwe	--	--	--	--	--	--	--	--	--	25,800	15,500	8,540	25,800	15,500	8,540
Total	25,600	17,000	26,200	8,040	4,960	4,710	--	--	--	283,000	169,000	92,300	316,000	191,000	123,000

-- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Harmonized Tariff Schedule of the United States code.

Source: U.S. Census Bureau.

TABLE 10

U.S. IMPORTS FOR CONSUMPTION OF CHROMIUM MATERIALS, BY TYPE[1]

HTS[2]	Type	2001 Quantity (kilograms)	2001 Value (thou-sands)	2002 Quantity (kilograms)	2002 Value (thou-sands)	Principal sources, 2002
	Metals and alloys:					
	Chromium metal:					
8112.20.3000	Waste and scrap, gross weight	41,000 r	$154 r	XX	XX	
8112.20.6000	Other than waste and scrap, gross weight	8,150,000	49,900	XX	XX	
8112.21.1000	Unwrought chromium powders, gross weight	XX	XX	776,000	$4,820	United Kingdom (48%); Russia (20%); Japan (16%); China (13%); Netherlands (2%).
8112.22.0000	Waste and scrap, gross weight	XX	XX	83,300	1,270	Russia (34%); Japan (27%); Germany (24%); Netherlands (10%); Republic of Korea (5%).
8112.29.0000	Other than waste and scrap, gross weight	XX	XX	6,570,000	36,800	Russia (28%); China (23%); France (24%); United Kingdom (18%); Kazakhstan (6%).
	Total	8,190,000	50,100	7,430,000	42,800	
7202.50.0000	Ferrochromium-silicon, gross weight	14,600,000	5,910	28,900,000	11,800	Kazakhstan (98%); Zimbabwe (2%).
7202.50.0000	Ferrochromium-silicon, contained weight	6,110,000	XX	12,000,000	XX	
	Chemicals, gross weight:					
	Chromium oxides and hydroxides:					
2819.10.0000	Chromium trioxide	10,500,000	17,200	16,500,000	24,500	Turkey (42%); Kazakhstan (41%); China (5%); United Kingdom (4%); Italy (3%); South Africa (3%); Russia (2%).
2819.90.0000	Other	2,820,000	10,500	2,860,000	9,640	China (33%); Japan (26%); Germany (23%); United Kingdom (9%); Belgium (2%); Colombia (2%); Spain (2%); Hong Kong (1%); Poland (1%); Russia (1%).
2833.23.0000	Sulfates of chromium	155,000	151	75,900	90	United Kingdom (91%); Brazil (9%).
	Salts of oxometallic or peroxometallic acids:					
2841.20.0000	Chromates of lead and zinc	111,000	224	135,000	395	Norway (39%); Republic of Korea (29%); Japan (24%); Colombia (8%).
2841.30.0000	Sodium dichromate	14,800,000	7,760	18,800,000	9,470	United Kingdom (99%); South Africa (1%).
2841.40.0000	Potassium dichromate	152,000	322	XX	XX	
2841.50.0000	Other chromates and dichromates; peroxochromates:	110,000	291	XX	XX	
2841.50.1000	Potassium dichromate	XX	XX	189,000	322	United Kingdom (46%); Russia (42%); Kazakhstan (11%); India (1%).
2841.50.9000	Other	XX	XX	241,000	555	Republic of Korea (68%); Austria (8%); Italy (8%); Mexico (8%); United Kingdom (8%).
2849.90.2000	Chromium carbide	267,000	2,900	261,000	2,760	Russia (43%); Japan (19%); Germany (14%); United Kingdom (12%); Canada (8%); France (4%).
	Pigments and preparations based on chromium, gross weight:					
3206.20.0010	Chrome yellow	5,870,000	16,300	6,610,000	14,900	Canada (59%); Republic of Korea (14%); Hungary (10%); Mexico (9%); China (4%); Colombia (3%); Germany (1%); Japan (1%).
3206.20.0020	Molybdenum orange	1,120,000	5,050	1,300,000	5,330	Canada (88%); Colombia (4%); United Kingdom (3%); Mexico (2%); Hungary (1%); Japan (1%).
3206.20.0030	Zinc yellow	128,000	98	--	--	
3206.20.0050	Other	1,390,000	4,100	1,220,000	3,420	France (57%); China (20%); Germany (10%); Italy (8%); Japan (2%); South Africa (1%).

[r]Revised. XX Not applicable. -- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown. Revised as of March 3, 2004.

[2]Harmonized Tariff Schedule of the United States code.

Source: U.S. Census Bureau.

TABLE 11
PRINCIPAL WORLD CHROMITE ORE PRODUCERS, 2002

Country[1]	Company
Albania	Albkrom (Government owned).
Australia	Consolidated Minerals Limited
	Pilbara Chromite Pty. Ltd.
Brazil	Cia. de Ferro Ligas da Bahia S.A.
	Mineracão Vila Nova Ltda.
	Magnesita S.A.
China	Huazang Smelter.
	Shashen.
	Xizang Kangjinla.
	Tibet Minerals Development Co., Ltd.
	Luobosa Mine.
	Xinjiang Karamay Gold Mine.
	Xinjiang Nonferrous Metals Industry Co.
Finland	Outokumpu Oy.
	Outokumpu Steel Oy.
	Outokumpu Chrome Oy.
India	Ferro Alloys Corporation Ltd.
	Indian Metals and Ferro Alloys Ltd.
	Indian Charge Chrome Ltd.
	Misrilall Mines Ltd.
	Mysore Mineral Ltd.
	The Orissa Mining Corporation Ltd.
	The Tata Iron and Steel Co. Ltd.
Indonesia	PT. Palabim Mining-PT. Bituminusa.
Iran	Faryab Mining Co.
Kazakhstan	Donskoy Ore Dressing Complex.
Madagascar	Kraomita Malagasy.
Oman	Oman Chromite Company SAOG.
Philippines	Benguet Corporation.
	Heritage Resources & Mining Corporation.
	Krominco Inc.
	Velore Mining Corporation.
Russia	Saranov Complex.
South Africa	Angovaal Ltd.
	Assmang Ltd.
	Dwarsrivier Chrome
	Assore Ltd.
	African Mining & Trust Co. Ltd.
	Rustenburg Minerals Development Co. (Pty.) Ltd.
	ASA Metals (Pty.) Ltd.
	Dilokong Chrome
South Africa--Continued	Bayer AG (Germany)
	Bayer (Pty.) Ltd.
	Rustenburg Chrome
	BHP-Billiton Plc. and Angol America Plc.
	Samancor
	Lannex (Pty.) Ltd.
	Eastern Chrome Mines
	Steelpoort section
	Doornbasch section
	Montrose section
	Tweenfontein section
	Western Chrome Mines
	Millsell section
	Elandsdrift section
	Mooinooi section
	Elandskraal section
	Hernic Ferrochrome (Pty.) Ltd.
	Hernic Ferrochrome
	National Manganese Mines (Pty.) Ltd.
	Buffelsfontein Mine
	S.A. Chrome & Alloys Ltd.
	Horizon Mine
	Xstrata A.G. (United Kingdom)
	Xstrata S.A. Mining Division
	Kroondal section
	Thorncliffe section
	Vereeniging Refractories (Pty.) Ltd.
	Marico Chrome Corp. Ltd.
Sudan	Advanced Mining Works Co. Ltd.
Turkey	Bilfer Madencilik A.S. (Bilfer Mining Inc.)
	Dedeman Madencilik Sanayi ve Ticaret A.S.
	Eti Elektrometalurji A.S. General Management
	Hayri Ögelman Mining Co. Ltd.
	Türk Maadin Sirketi A.S.
United Arab Emirates	Derkek Raphael & Co.
	Derwent Mining Ltd.
Zimbabwe	Maranatha Ferrochrome (Pvt.) Ltd.
	Amble Mining Co.
	Zimasco (Pvt.) Ltd.
	Zimbabwe Alloys Ltd.

[1]Other chromite-producing countries included Burma, Cuba, Pakistan, and Vietnam.

TABLE 12
PRINCIPAL WORLD FERROCHROMIUM PRODUCERS, 2002

Country	Company
Albania	Darfo Albania.
Brazil	Acesita S.A.
	Cia. de Ferro Ligas da Bahia S.A.
China	Dandong Ferroalloy Plant.
	Emei Ferroalloy (Group) Co. Ltd.
	Gansu Huazang Metallurgical Group Co. Ltd.
	Hanzhong Ferroalloy Works (Government owned).
	Hengshang Iron & Steel
	Hunan Ferroalloy (Government owned).
	Hunan Lengshuijiang Electrochemical Works.
	Jiangyin Ferroalloy Factory (Government owned).
	Jilin Dongfeng Ferroalloy Works.
	Jilin Ferroalloy Group Co. Ltd.
	Jilin Huinan Ferroally Works.
	Jinzhou Ferroalloy (Group) Co. Ltd.
	Liaoyang Ferroalloy Group Corp.
	Mengzang Ferroalloy Co. Ltd.
	Nanjing Ferroalloy Plant (Government owned).
	Ningjin Metal Smelting Co. Ltd.
	Northwest Ferroalloy Works.
	Qinghai Datong Ferroalloy Works.
	Qingzang Ferroalloy Co. Ltd.
	Quinhai Sanchuan Ferroalloy Co. Ltd.
	Taonan Ferroalloy Works.
	Urad Zhongqi Ferrochrome Group Corp.
	Xibei Ferroalloy Works (Government owned).
	Zhejiang Hengshan Ferroalloy Works.
Croatia	Dalmacija Ferro-Alloys Works.
Finland	Outokumpu Oy.
	Outokumpu Steel Oy.
	Outokumpu Chrome Oy.
Germany	Elektrowerk Weisweiler GmbH.
India	Andhra Ferro Alloys Limited.
	Baroda Ferro-Alloys
	Deepak Ferro-Alloys Pvt. Ltd.
	Ferro-Alloys Corp. Ltd.
	Charge Chrome Plant.
	Ferro-Alloys Unit.
	GMR Vasavi Industries Ltd.
	IMFA Group
	Indian Metals and Ferro-Alloys Ltd.
	Indian Charge Chrome Ltd.
	India thermit Corp. Ltd.
	Industrial Development Corp.
	Ferro-Chrome Plant
	Ispat Alloys Ltd.
	Jalan Ispat Casting Ltd.
	Jindal Strips Ltd.
	Ferro Alloys Division.
	Maithan Alloys Ltd.
India-Continued	Sree Sarada Alloys Ltd.
	The Sileal Metallurgie Ltd.
	The Tata Iron and Steel Co. Ltd.
	VBC Ferro-Alloys Ltd.
Iran	Faryab Mining Co.
	Abadan Ferroalloys Refinery.
Japan	Nippon Denko Co., Ltd.
	NKK Corp.
	NKK Materials Co. Ltd.
	Showa Denko K.K.
	Shunan Denko K.K.
Kazakhstan	Aksusky Ferroalloy Plant.
	Aktyubinsk Ferroalloy Plant.
Norway	Elkem ASA.[1]
Russia	Chelyabinsk Electrometallurgical Integrated Plant.
	Klutchevsk Ferroalloy Plant.
	Metall Joint Venture.
	Serov Ferroalloys Plant.
Slovakia	Oravske Ferozliatinarske Zavody.
Slovenia	Tovarna Dusika Ruse-Metalurgija d.d.
South Africa	Anglovaal Mining Ltd. and Assore Ltd.
	Assmang Ltd.
	Machadodorp Works
	BHP-Billiton Plc. and Anglo American Corp. Plc.
	Samancor Ltd.
	Bathlako Ferrochrome
	Ferrometals
	Middelburg Ferrochrome
	Tubatse Ferrochrome
	Hernic Ferrochrome (Pty.) Ltd.
	Hernic Ferrochrome
	Xstrate A.G. (United Kingdom)
	Xstrate South Africa (Pty.) Ltd.
	Xstrata S.A. Chrome Division
	Rustenburg Works
	Wonderkop Works
	Lydenburg Works
	S.A. Chrome & Alloys
	S.A. Chrome
	A.S.A. Metals (Pty.) Ltd.
	Dilokong Ferrochrome
Sweden	Vargön Alloys AB.
Turkey	Eti Holdings.
	Eti Elektromatalurji.
	Eti Krom A.S.
United States	Eramet Marietta Inc.
Zimbabwe	Maranatha Ferrochrome (Pvt.) Ltd.
	Zimasco (Pvt.) Ltd.
	Zimbabwe Alloys Ltd.

[1]Ferrochromium production stopped in 2002.

TABLE 13
CHROMITE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country[3]	1998	1999	2000	2001	2002
Afghanistan[4]	3,409	4,318	5,345	5,682 r	--
Albania[5]	102,189	71,434	63,000	129,700	135,000
Australia	80,000	70,000	90,000	11,800	132,665
Brazil[6]	537,426 r	488,392 r	602,971 r	408,549 r	279,648
Burma[e]	4,059 [7]	2,500 r	1,000 r	1,000 r	--
China[e]	220,000 r	220,000 r	208,000 r	182,000 r	180,000
Cuba	46,000	52,000	56,300	50,000 r	46,000
Finland	498,075	597,438	628,414	575,126	566,090
Greece[4]	4,432	2,273	--	--	--
India	1,311,310	1,472,766	1,946,910	1,677,924	1,900,000
Indonesia	4,700	6,355	-- r	-- r	--
Iran	211,555	254,685	153,000	104,905 r	80,000
Kazakhstan	1,602,700	2,405,600	2,606,600	2,045,700 r	2,369,400
Macedonia	5,000	5,000	5,000 e	5,000 e	5,000 e
Madagascar	104,300	--	118,750	51,900	11,000
Oman	28,684	26,004	15,110 r	30,100 r	27,444
Pakistan	77,500	58,000	119,490	64,000	62,005
Philippines	53,871	19,566	26,361 r	26,932 r	23,703
Russia	150,000	115,100	92,000	69,926	70,000 e
South Africa	6,480,000	6,817,050	6,622,000 r	5,502,010	6,435,746
Sudan[e]	30,500	48,000	28,500	20,500	14,000
Turkey	1,404,470	770,352	545,725	389,759	313,637
United Arab Emirates[e]	76,886 [7]	60,000	30,000	10,000	10,000
Vietnam	59,000	58,500	76,300 r	80,000 r	82,000
Zimbabwe	605,405 r	653,479 r	668,043 r	780,150	749,339
Total	13,700,000 r	14,300,000 r	14,700,000 r	12,200,000 r	13,500,000

[e]Estimated. [r]Revised. -- Zero.

[1]World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2]Table includes data available through June 25, 2003.

[3]Figures for all countries represent marketable output unless otherwise noted.

[4]Gross weight estimated assuming an average grade of 44% Cr_2O_3.

[5]Direct shipping plus concentrate production.

[6]Average Cr_2O_3 content was as follows: 1998-99--39% (revised); 2000--42% (revised); 2001--42.6% (revised); and 2002--43% (estimated).

[7]Reported figure.

TABLE 14
FERROCHROMIUM: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country	1998	1999	2000	2001	2002[e]
Albania	30,252	28,120	12,500 r	11,900 r	22,800
Brazil[3]	72,507	90,784	142,522	110,462 r	169,658 4
China[e]	424,000	400,000	450,000	310,000 r	400,000
Croatia	11,771	--	15,753	361	--
Finland	230,906	256,290	260,605 r	236,710	248,181 4
Germany	20,879	16,960	21,600	19,308	20,018 4
India[5]	345,125	312,140	376,693	267,395 r	311,927 4
Iran	13,745	13,680	11,505	8,430	15,000
Italy	11,487	--	--	-- e	--
Japan[3]	142,931	119,777	130,074	111,167	91,937 4
Kazakhstan	535,000	731,563	799,762	761,900	835,800 4
Norway	174,678	159,714	153,500	82,600	61,100
Poland	4,200	--	--	-- e	--
Romania	873	--	--	-- e	--
Russia	203,000	249,000	274,000	210,600	210,000
Slovakia	11,715	6,986	17,702	5,968	5,695 4
Slovenia	10,621	560	--	--	--
South Africa[6]	2,025,300	2,155,202	2,574,000	2,141,000	2,200,000
Spain	1,145	935	905	-- e	--
Sweden	123,958	113,140	135,841	109,198	118,823 4
Turkey	110,175	99,105	97,640 r	50,735	11,200
United States[7]	W	W	W	W	W
Zimbabwe	246,782	244,379	246,324	243,584 r	258,164 4
Total	4,750,000	5,000,000	5,720,000	4,680,000	4,980,000

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." -- Zero.
[1]World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.
[2]Table inculdes data available through August 21, 2003.
[3]Includes high- and low-carbon ferrochromium.
[4]Reported figure.
[5]Includes ferrochrome and charge chrome.
[6]Includes high- and low-carbon ferrochromium and ferrochromiumsilicon..
[7]Includes chromium metal, high- and low-carbon ferochromium, ferochromiumsilicon, and other chromium materials.

TABLE 15
WORLD CHROMIUM ANNUAL PRODUCTION CAPACITY OF CHROMITE ORE, FERROCHROMIUM, CHROMIUM METAL, CHROMIUM CHEMICALS, AND STAINLESS STEEL IN 2002[1]

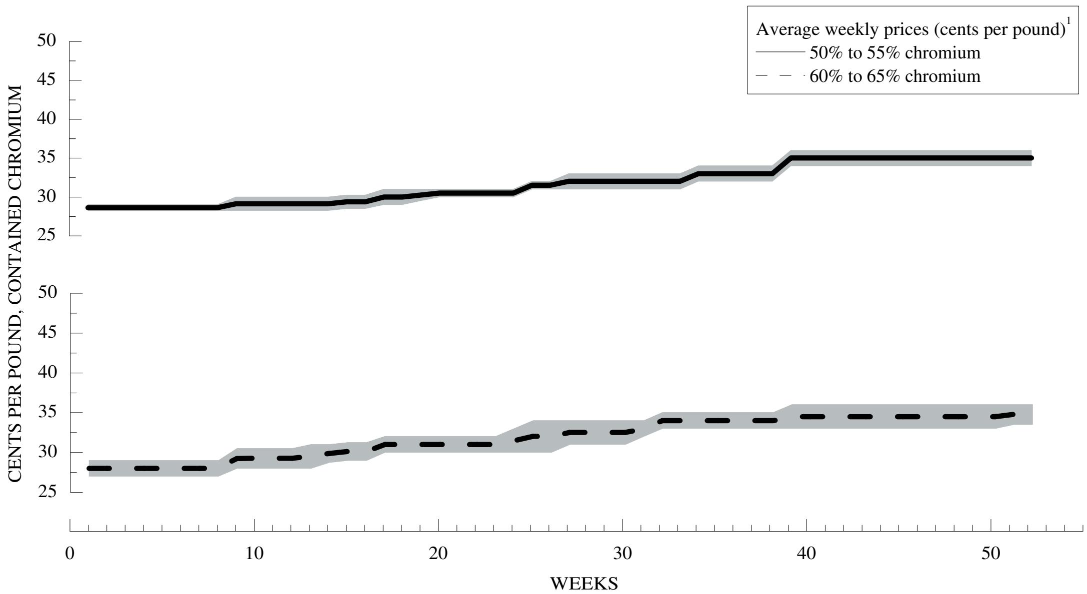
(Thousand metric tons of contained chromium)

Country	Ore	Ferro-chromium	Metal	Chemicals	Stainless steel
Afganistan	2	--	--	--	--
Albania	48	22	--	--	--
Argentina	--	--	--	13	--
Australia	72	--	--	--	--
Austria	--	--	--	--	8
Bangladesh	--	--	--	--	3
Belgium	--	--	--	--	123
Brazil	101	109	--	--	65
Burma	1	--	--	--	--
Canada	--	--	--	--	39
China	48	272	6	70	64
Cuba	17	--	--	--	7
Czech Republic	--	--	--	--	5
Egypt	--	--	--	--	3
Finland	189	139	--	--	109
France	--	--	7	--	204
Germany	--	17	1	--	272
Greece	4	--	--	--	--
India	586	196	(2)	4	122
Indonesia	2	--	--	--	--
Iran	77	9	--	2	--
Italy	--	--	--	--	221
Japan	--	97	1	17	672
Kazakhstan	903	512	2	37	--
Korea, Republic of	--	--	--	--	269
Macedonia	2	--	--	--	--
Madagascar	42	--	--	--	--
Norway	--	106 [3]	--	--	--
Oman	9	--	--	--	--
Pakistan	36	--	--	3	--
Philippines	26	--	--	--	--
Poland	--	--	--	--	--
Russia	46	180	16	31	38
Slovakia	--	10	--	--	--
Slovenia	--	--	--	--	12
South Africa	2,060	1,470	--	23	92
Spain	--	--	--	--	204
Sudan	14	--	--	--	--
Sweden	--	86	--	--	138
Taiwan	--	--	--	--	231
Turkey	466	69	--	17	54
Ukraine	--	--	--	--	33
United Arab Emirates	23	--	--	--	--
United Kingdom	--	--	7	44	92
United States	--	20	3	38	374
Vietnam	16	--	--	--	--
Zimbabwe	214	221	--	--	--
Total	5,000	3,530	43	299	3,450

-- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Less than 1/2 unit.
[3]Ferrochromium production stopped in 2002.

FIGURE 1

U.S. IMPORTED HIGH-CARBON FERROCHROMIUM IN 2002

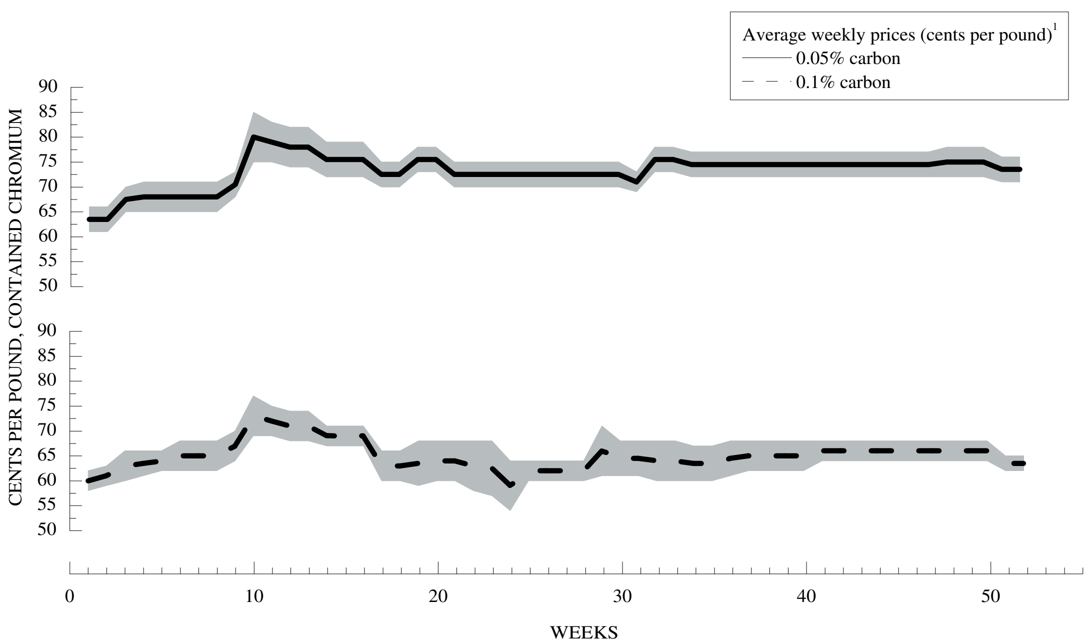


[1]Average weekly price shown against price range background.

Source: Platts Metals Week

FIGURE 2

U.S. IMPORTED LOW-CARBON FERROCHROMIUM IN 2002



[1]Average weekly price shown against price range background.

Source: Platts Metals Week